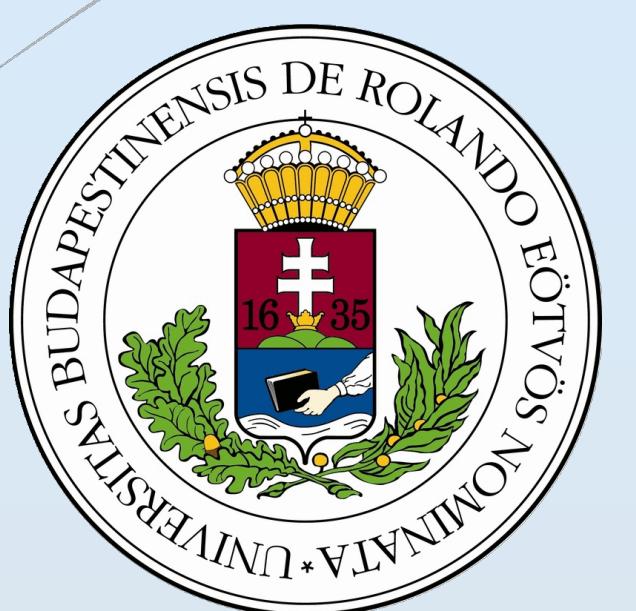




# Collision energy dependent Levy analysis of HBT correlation functions in Au+Au collisions at PHENIX

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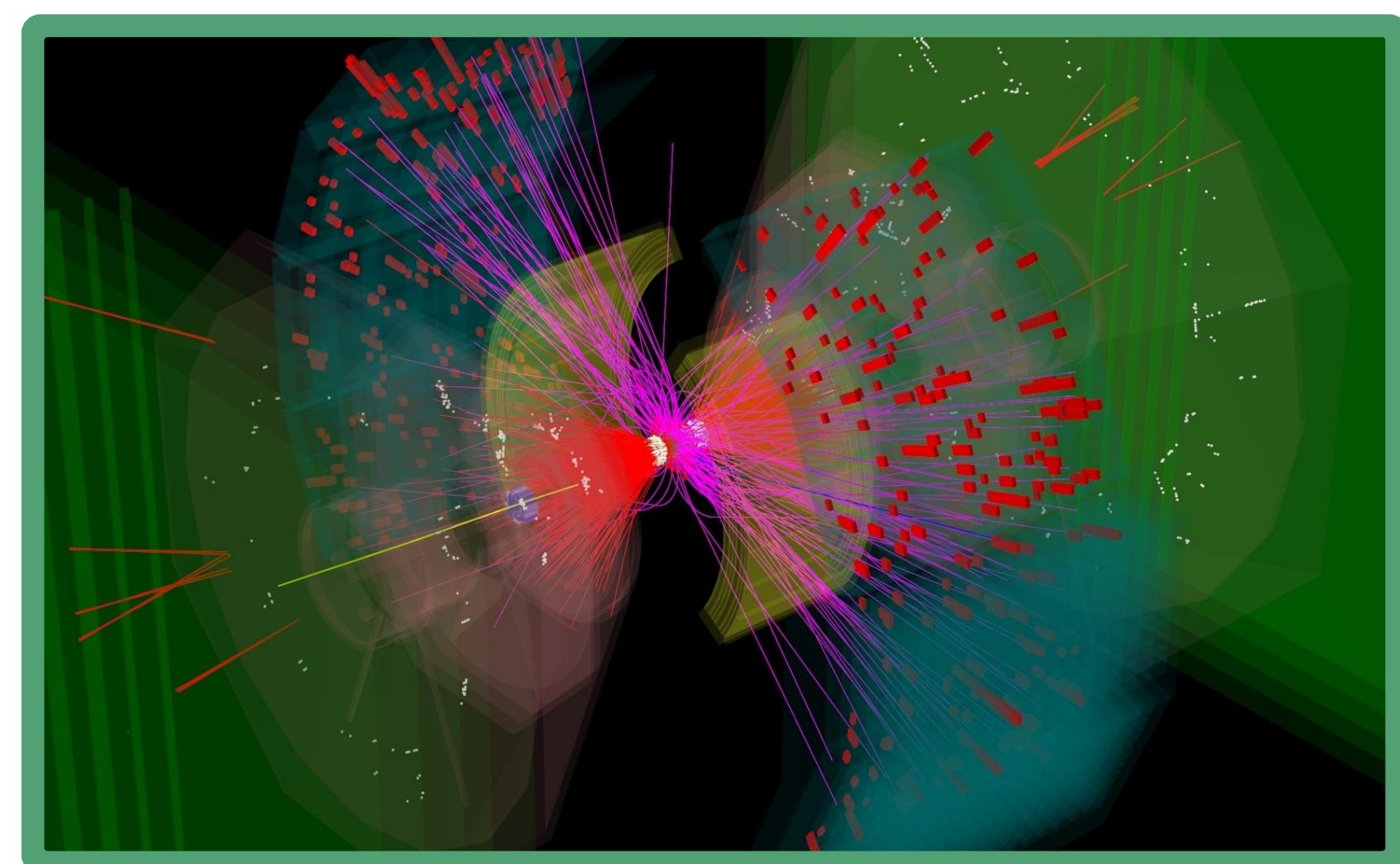
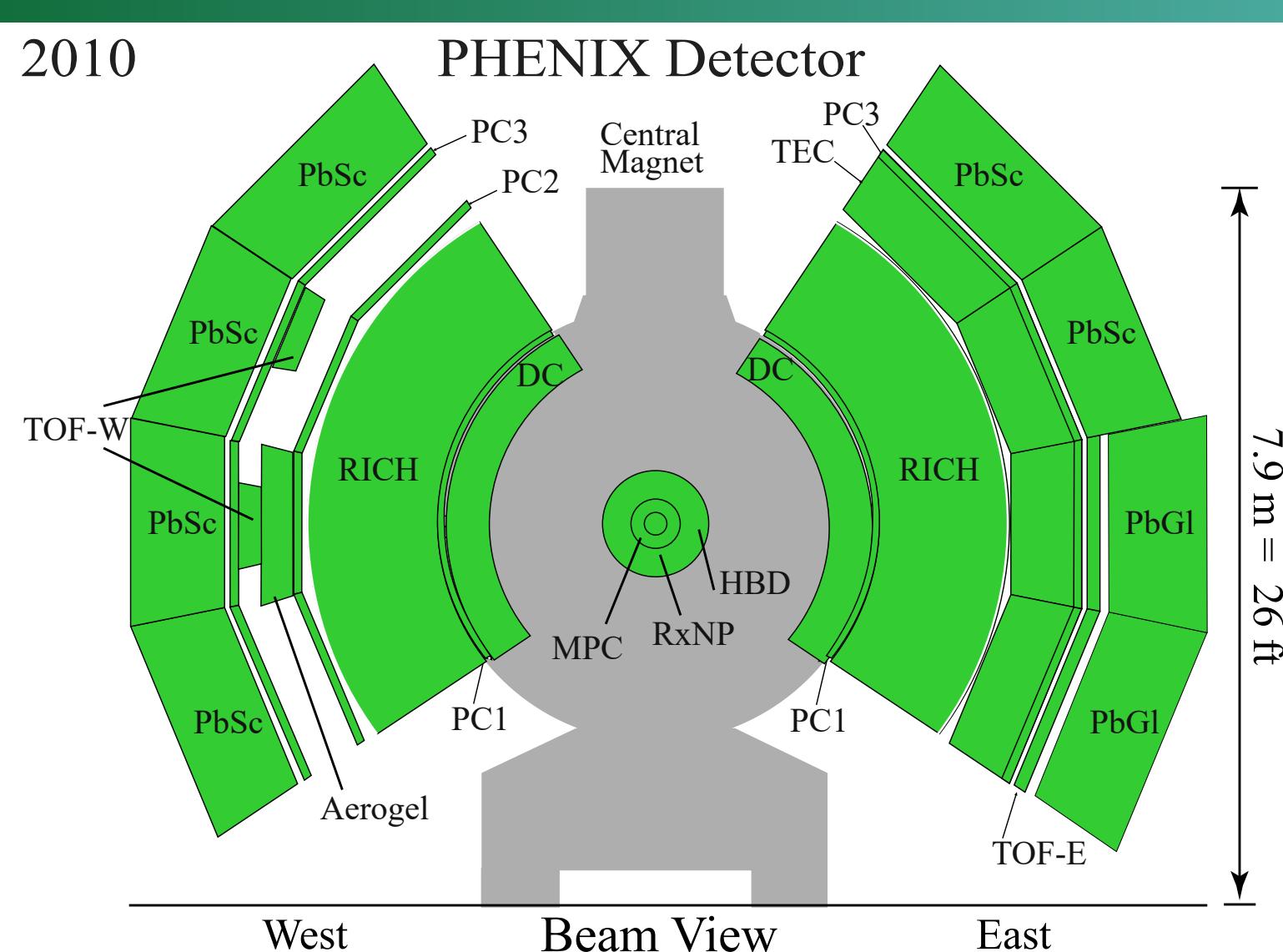


55th International School of Subnuclear Physics, Erice, June 2017

**PHENIX**

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## The PHENIX experiment at RHIC



• Au+Au BES: 200, 62, 39, 27, 19, 15 GeV

## Introduction to Bose-Einstein correlations

- $N_1(p), N_2(p)$  - invariant momentum distributions, the definition of the correlation function:

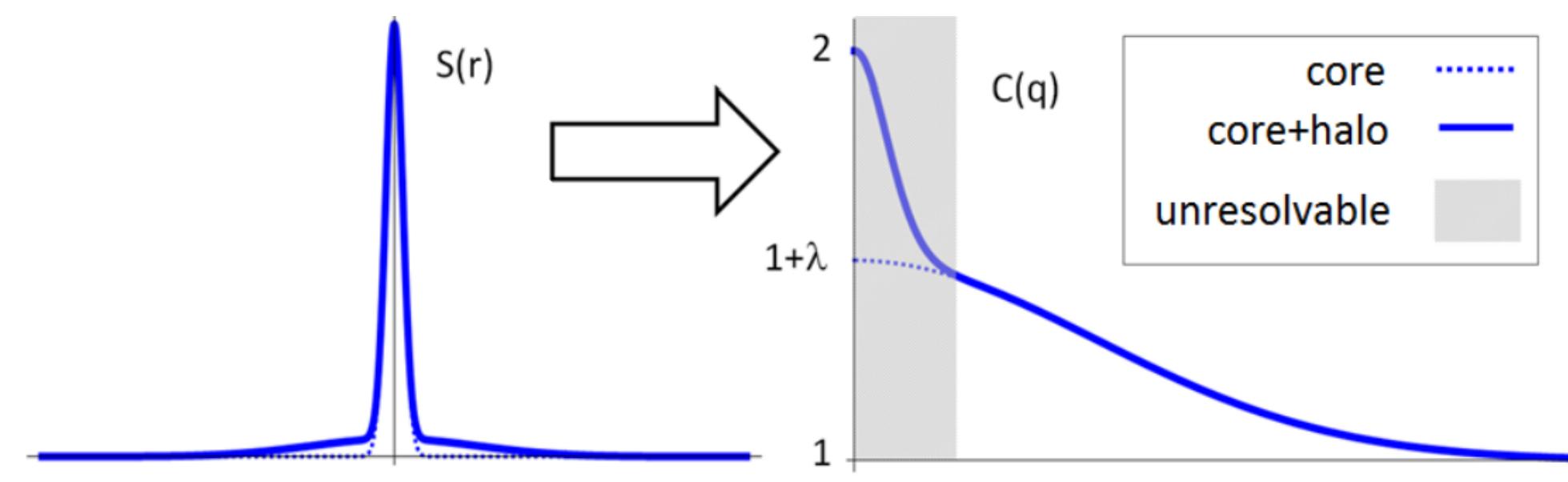
$$C_2(p_1, p_2) = \frac{N_2(p_1, p_2)}{N_1(p_1)N_1(p_2)}, \text{ where } N_2(p_1, p_2) = \int S(x_1, p_1)S(x_2, p_2)|\Psi_2(x_1, x_2)|^2 d^4x_2 d^4x_1 \quad (1)$$

- $S(x, p)$  source function (usually assumed to be Gaussian - Levy is more general)
- $\Psi_2$  two-particle wave function - interaction free case:  $|\Psi_2|^2 = 1 + \cos(qx)$
- If  $k_1 \simeq k_2$ :  $C_2 \rightarrow$  inverse Fourier-trf.  $\rightarrow S$

$$C_2(q, K) \simeq 1 + \left| \frac{\tilde{S}(q, K)}{\tilde{S}(0, K)} \right|^2, \quad \tilde{S}(q, k) = \int S(x, k) e^{iqx} d^4x \quad K = (k_1 + k_2)/2 \\ x = x_1 - x_2, q = k_1 - k_2$$

## Final state interactions, resonances

- Identical charged pions - Coulomb interaction distort the simple picture
  - different methods of handling, e.g. Coulomb-correction:  $C_{B-E}(q) = K(q) \cdot C_{\text{meas.}}(q)$
- Resonance pions reduce the corr. strength [1, 2]
- Core-Halo model:  $S = S_C + S_H$
- Primordial pions - Core  $\lesssim 10$  fm
- Resonance pions - from very far regions - Halo
- Corr. strength  $\rightarrow$  C-H ratio:  $\lambda = \left( \frac{N_C}{N_C + N_H} \right)^2$



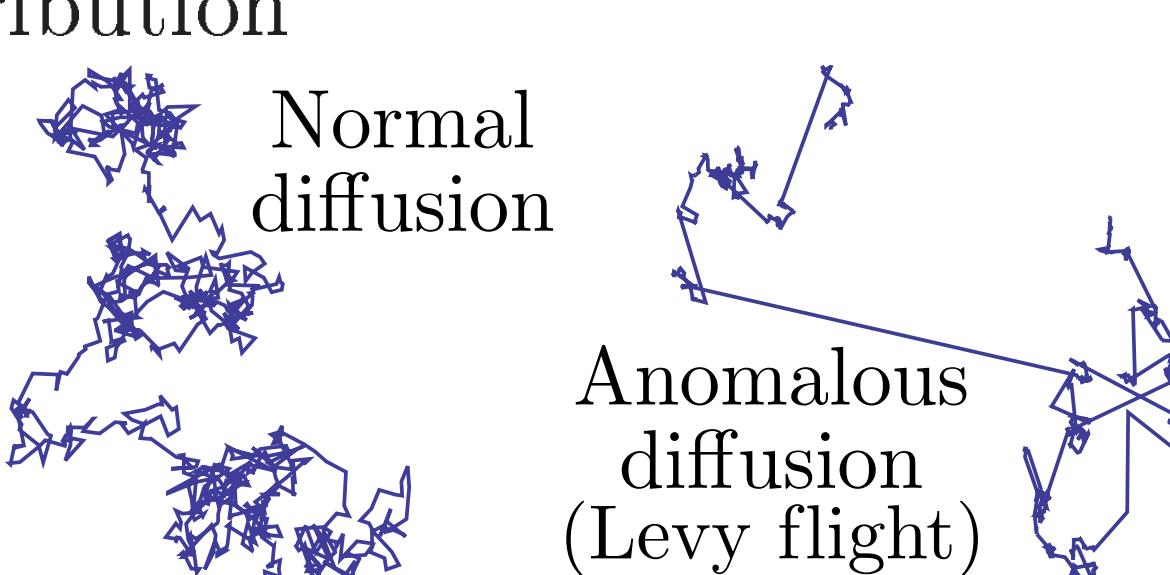
## The Levy distribution as source function

- In expanding hadron resonance gas, mean free path increases with time  $\rightarrow$  Levy flight

$$\mathcal{L}(\alpha, R, r) = \frac{1}{(2\pi)^3} \int d^3q e^{iqr} e^{-\frac{1}{2}|qR|^\alpha} \quad \begin{cases} \alpha = 2 : \text{Gaussian} \\ \alpha = 1 : \text{Cauchy} \end{cases}$$

- Shape of the correlation func. with Levy source [3]:

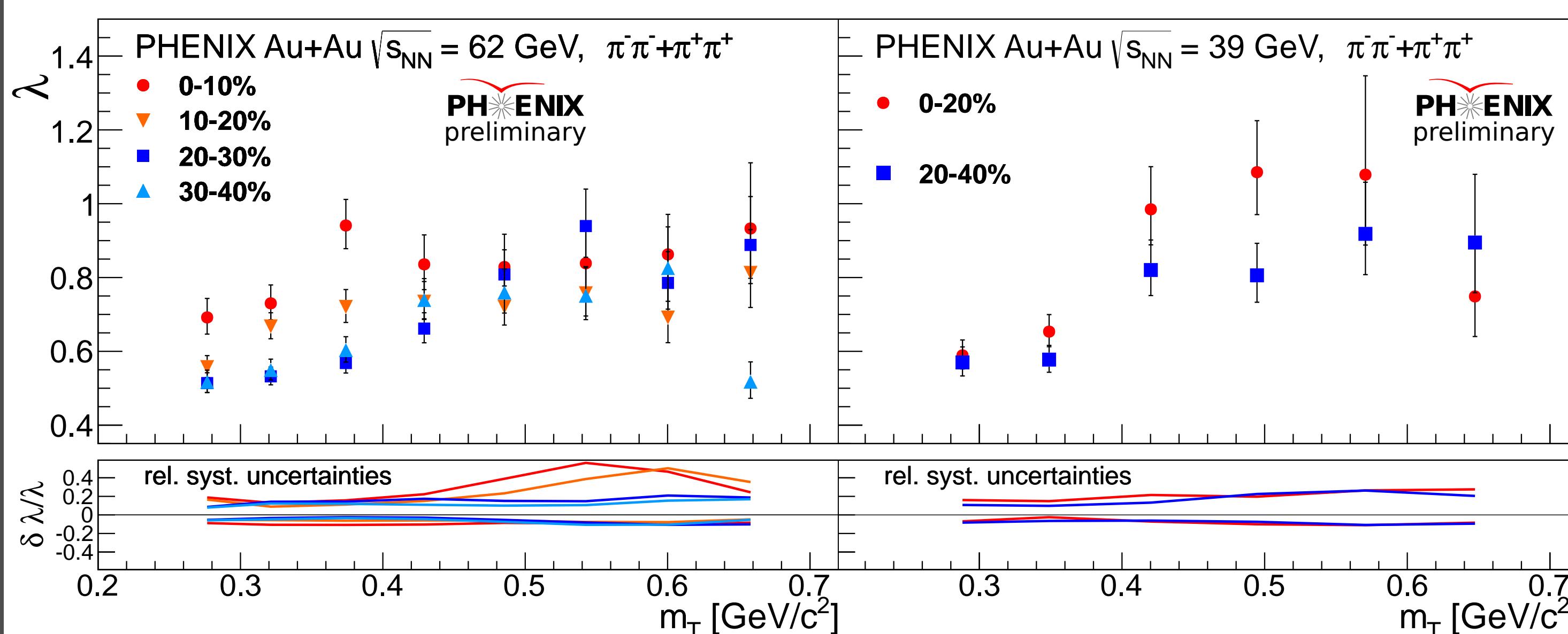
$$C_2(|k|) = 1 + \lambda \cdot e^{-(2R|k|)^\alpha}$$



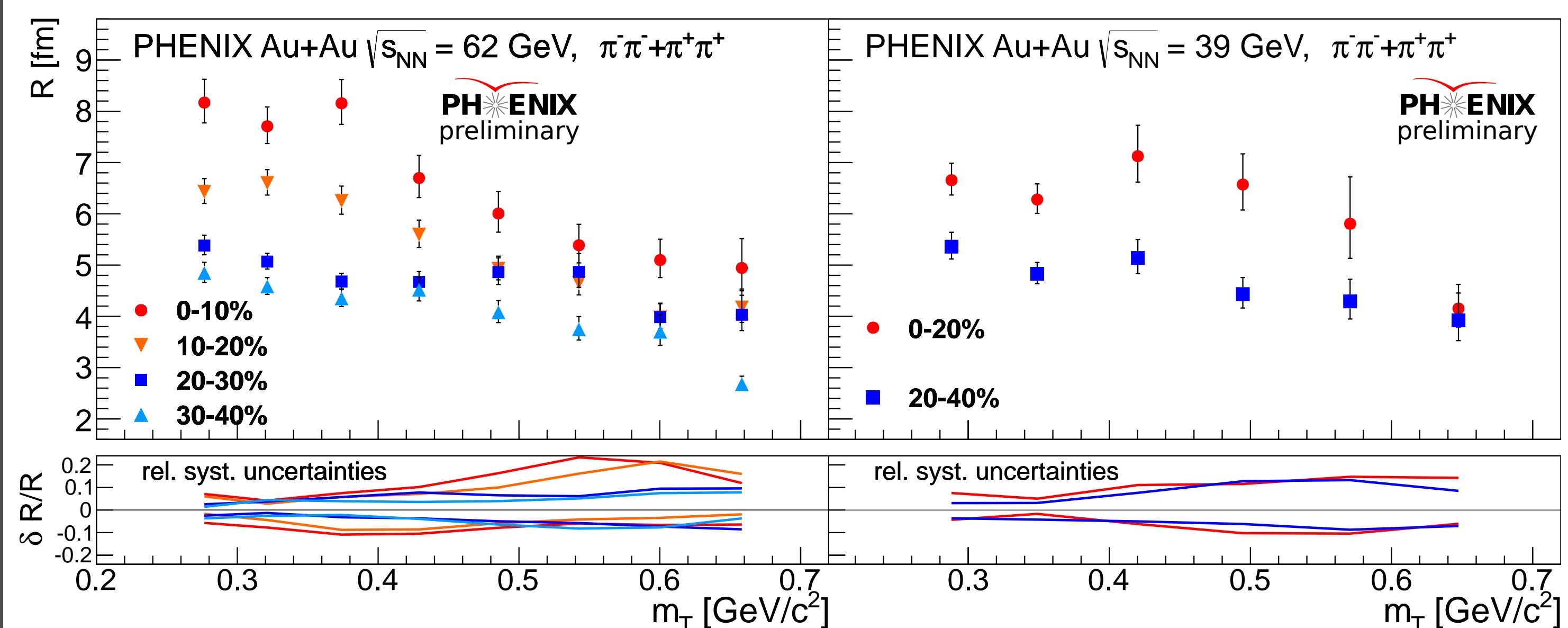
## Critical behavior

- Crit. behavior  $\rightarrow$  described by crit. exponents
- At CEP in 3 dim.  $\langle \Psi(0)\Psi(r) \rangle \propto r^{-1-\eta} \quad \alpha = \eta$
- Levy distr.  $\rightarrow$  spatial corr.  $\propto r^{-1-\alpha}$
- QCD universality class  $\leftrightarrow$  3D Ising [4]
- $\eta(\text{CEP}) = 0.03631(3)$  from 3D Ising [5]
- $\eta(\text{CEP}) = 0.5 \pm 0.05$  from rfd.3D Ising [6]

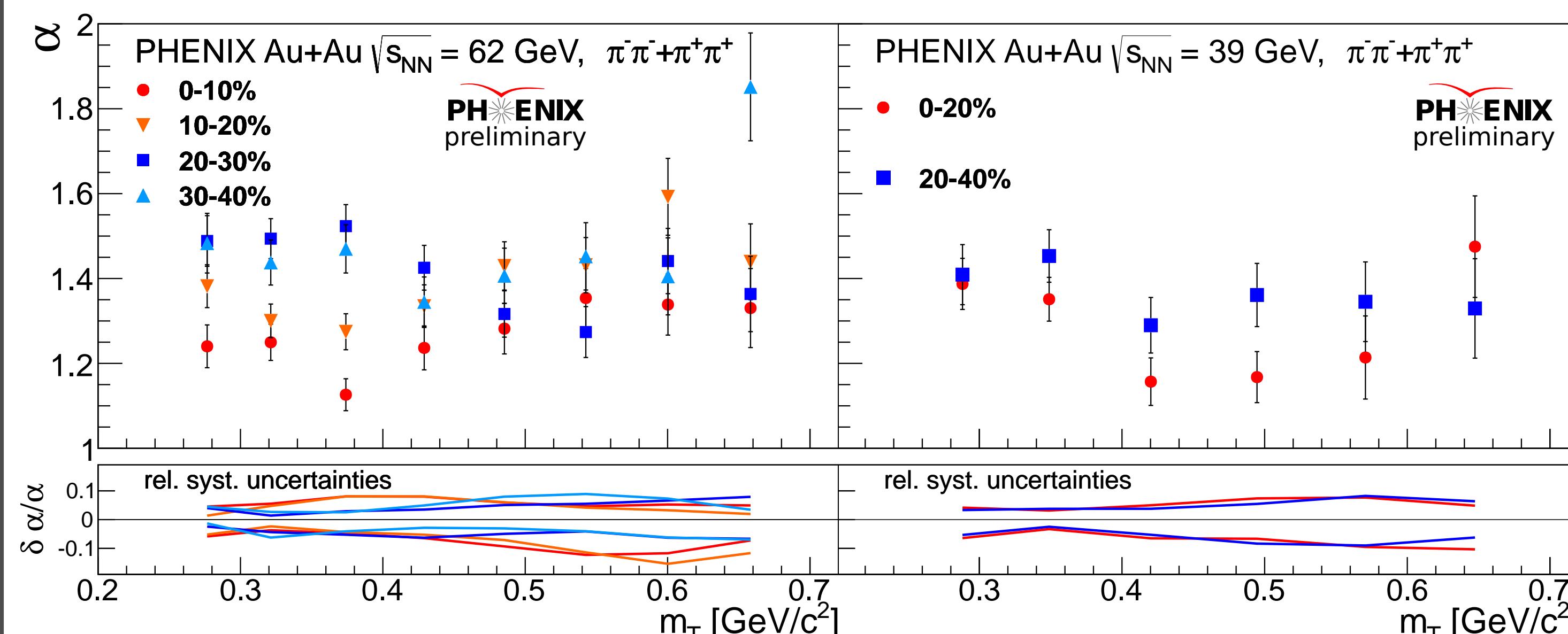
## Low $m_T$ suppression in correlation strength $\lambda$



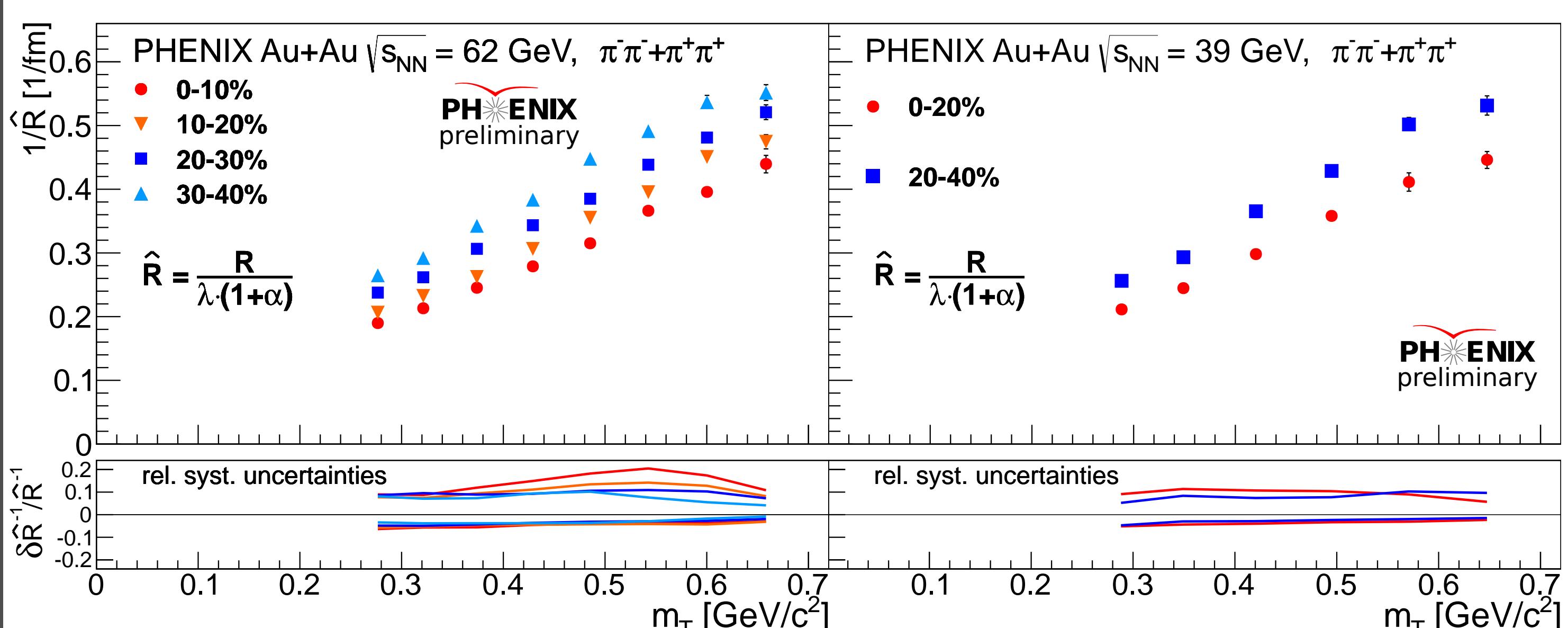
## Decreasing trend, geom. cent. dep. of Levy scale R



## Levy exponent alpha > 0.5 (CEP limit) and < 2 (hydro limit)



## Newly found scaling parameter 1/R linear in m\_T



## Summary

- Bose-Einstein corr. with Levy source
  - Good agreement with data
  - Levy exponent  $\alpha \equiv$  crit. exp.  $\eta$
  - $\alpha$  vs.  $\sqrt{s_{NN}}$   $\leftrightarrow$  proximity of CEP
  - Motivation for coll. energy dep. meas.
- Preliminary Levy HBT results
  - Magnitude of Levy scale is similar at 62 & 39 GeV
  - Levy exponent  $\alpha$  is far from hydro limit (2)
  - Levy exponent  $\alpha$  is far from CEP limit (0.5)
  - Increase of halo fraction is present at small  $m_T$
  - Scaling of  $\hat{R}$  as  $1/m_T$  is valid at 62 & 39 GeV

This research was supported by the funding agencies listed in ref. [7].

In addition, D. K. was supported by the ÚNKP-16-2 New National Excellence program of the Hungarian Ministry of Human Capacities.

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